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ABSTRACT

The success of German firms' searches for qualified personnel to fill openings in skilled occupations was examined through a statistical analysis of data from the Institut fur Arbeitsmarkt- und Berufsforschung der Bundesanstalt fur Arbeit's (IAB) establishment panel for 2000. An employer search model was used to explain the current German debate surrounding the additional demand for skilled labor. In the theoretical approach adopted, firms decided to use an optimal strategy for searching for new staff. For this purpose, firms set a minimum qualification level for applications with whom they concluded employment contracts. If qualification requirements must be determined exogenously, however, pursuing an optimal search strategy may become impossible and a firm's demand for labor may remain unsatisfied. Analysis of data from the IAB establishment panel established that it is particularly difficult for German employers to fill vacancies for engineers and computer scientists. Firms affected by unfilled vacancies often reported an absence of suitable applicants. The hypothesis of the search model was confirmed by multivariate analysis of the number of unfilled vacancies. Wage level, economic trends, and selected company characteristics also proved important. (Contains 14 figures and 19 references. Four tables presenting Poisson regressions, descriptions of the study variables, regional demographic structure types, and data on industry structure are appended.) (MN)

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Arnd Kölling

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Bundesanstalt für Arbeit
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- observation of and forecasts for the German labour market
- labour market statistics
- labour market theory and policy
- evaluation of employment programmes
- regional and international labour markets
- occupation sociology
- research in skills and qualifications
- technological development and the labour market
- business and personnel management

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0 Abstract

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0 Abstract

This study takes as a starting point the current debate surrounding the additional demand for skilled labour, and makes use of an employer search model in order to explain it. In these theoretical approaches the firms decide upon an optimal strategy for searching for new staff. For this they lay down a minimum qualification level for applicants with whom they conclude a contract of employment. If for technical or other reasons these qualification requirements are determined exogenously, however, it might no longer be possible to pursue an optimal search strategy. This may lead to an unsatisfied demand for labour on the part of the firms. The data of the IAB establishment panel for 2000 support the considerations. The descriptive analysis shows that it is particularly difficult to fill vacancies for engineers and computer scientists. Firms affected by unfilled vacancies often report that there are no suitable applicants. Multivariate analyses on the number of unfilled vacancies also confirm the hypotheses of the search model. In particular technical and organisational changes raise the number of unfilled vacancies for graduates. However, the wage level, the economic trend and other company characteristics are also of importance. It can thus be seen that the approach of an employer search model can help very well to explain the current situation on the labour market for highly qualified workers.

1 Introduction

In the debate surrounding the lack of skilled personnel, the problem is usually portrayed as a lack of qualified employees. This lack is understood as an unavailability of certain qualifications which is permanent or can only be reduced in the long term. The available supply of qualified labour is claimed to be too small to meet the strongly increased demand. In economic theory, however, permanent unavailabilities are only very rarely brought into play to explain economic processes. Although the supply of and demand for certain qualifications determine the skilled labour situation on the labour market, market malfunctions are often held responsible for a result in which not all the market participants are satisfied. Above all unequally distributed information about the other participants on the markets is of importance here. On the labour market, workers and firms therefore frequently use search and matching processes to describe the materialisation of employment relationships at individual level.

Whereas in a simple market model the wage plays the decisive role in balancing supply and demand on the labour market, in matching models the search efforts and the particular ideas about the minimum qualification level for the jobs are also taken into consideration. This makes it possible for example to explain wage differences which are not due to the employees' different qualifications. Approaches for explaining the duration of vacancies or of search unemployment (cf. Franz 1999, 213) also result. Whereas a number of papers have dealt with the behaviour of job-seekers (cf. Franz 1999, 207), there are relatively few studies which examine explicitly the behaviour of firms as searchers (cf. Neubäumer 1992 or Burdett & Cunningham 1998, 446). It can be assumed, however, that the search behaviour of firms will increase in importance if the supply of certain qualifications dries up.

2 Theoretical considerations

A number of models deal with the search behaviour of workers. Starting out from Stigler's seminal work (1961), there are in the meantime several generations of search models each of which has been refined further (cf. Franz 1999, 206ff.). Fundamentally the search process in these models consists of two stages. First a certain probability of the seeker receiving an offer is assumed. Besides depending on personal characteristics such as education and training, work experience, gender and age, this probability also depends on the individual search efforts. In addition the probability of receiving an offer falls as the attractiveness of the job increases. In formal terms a negative connection between the wage level offered and the chance of a job offer is assumed here. Additionally there are other characteristics which have an effect on the likelihood of a job offer. These include the general situation on the labour market and the region or sector to which the job-seeker and firm belong.

Under the given probability of a job offer, the job-seeker then has to decide whether to accept an offer or not. In the theoretical models this decision is based on the wage level that only just satisfies the worker's demands. It must be taken into account here, however, that there are also non-monetary job features that influence a decision, e.g. company car, quality of the place of residence or work, time needed to travel to work and so on. In order to derive a job-seeker's optimal wage demand it is necessary to make assumptions regarding the distribution of all wage offers. From this distribution it is possible to derive the probability of obtaining an offer which is equal to or greater than the reservation wage rate. Together with the chance of the job-seeker receiving an offer at all, it is possible to determine from the information a probable search duration and with that the expected costs of the search, which can then be related to the returns from an available wage offer. In the optimum a reservation wage is set at which the expected wage rate at the time of the search is equal to the expected returns from the continued search. If it is assumed that the results of the search are evaluated after each search step and that the information has some influence on the further search (sequential search), then the knowledge about the actual distribution of the wage offers may increase. In this way the search can be improved and the matching process becomes more effective.

Compared with the models for job-seekers, very little attention has been paid to portraying the search process conducted by the job providers (cf. Neubäumer 1992, 14ff.; Burdett & Cunningham 1998, 446). One reason for this may be the fact that the structures of the models for job-seekers described above were applied to firms. Secondly, there were hardly any accessible data available for monitoring the search behaviour of firms. Furthermore the labour market situation is also of great importance. If during times of high unemployment there is a lack of jobs to be filled, then the search activities of job providers are not of great significance. It can be assumed that firms receive a sufficient number of applications even without making special efforts. The success of the search then depends more on the job-seekers' behaviour than on the action taken by the firms. In times when qualified workers are scarce it becomes more difficult for the individual firms to recruit suitable qualified personnel. Then the problems concerning qualified labour depend considerably on the firms' search behaviour.

In formal terms, when describing the employer as the searcher it is possible to proceed in a similar way to the models in which the worker appears as the searcher. In addition to a contact probability of a job offer arising, there is also a probability of an employment contract being concluded. Unlike the reservation wage that is used by the job-seekers, the measure used by

the employers is a minimum of productivity which must be available on concluding an employment contract (cf. on this matter e.g. Neubäumer 1992, 14ff.).

In addition to the uncertainty concerning the distribution of the productivity across all applicants, there is the additional problem for the firms that an applicant's individual capacity to work is very difficult to determine. Such a screening process can be associated with a very high level of effort and expenditure. Alternatively, employers can also use applicants' "signals" for their selection. These include for example formal qualifications, such as school and university qualifications or training. On the other hand directly individual characteristics can be used for the selection. This can also lead to so-called "statistical discrimination", if for instance gender, physical constitution or age are regarded as criteria and thus cause a discrimination e.g. of women or the disabled or other groups.

Besides the company characteristics such as establishment size, industry, regional location, other factors that influence the probability of an application also include search efforts and remuneration. In addition to making a job being more attractive, the level of the wage rate can also lead to an adverse selection of applicants. A higher wage rate may also imply that the firm will demand more of its employees. Then less productive workers would refrain from applying.

The necessary qualifications depend among other things upon the methods of work and production and/or the technical equipment of the firm. If one follows the hypothesis here that organisational or technical changes lead to a greater demand for qualified employees, then the use of modern technologies or recently introduced changes in the organisation of work can give indications of the firms' minimum requirements. The firms could, however, also pursue the strategy of increasing the wage rate simultaneously to the qualification-related requirements in order to fill the job vacancies rapidly (Acemoglu & Shimer 2000). The advantage of such behaviour lies in the more rapid utilisation of these workers' higher labour productivity. In this way large investments in new technologies become profitable more quickly and the firm gains itself an advantage in this way. In contrast, firms for which such a strategy does not pay off do not invest in modern technologies and the wage rate remains low. The minimum qualification level can be derived from the distribution of the abilities across all workers and from the costs and returns of accepting an application or of continuing the search.

The calculations concerned with an optimal minimum qualification level therefore disregard lower limits resulting from necessary abilities e.g. indispensable technical knowledge. If the qualification level needed is above the minimum qualification level, then an optimal search process as described above is not automatically possible. Possibilities for achieving equilibrium can be seen for example in altering the search efforts and the wage level. However, this not only increases the probability of the firm receiving an application, it raises the costs too. Then no optimal company search might be possible. This may lead to what firms experience as "shortages of skilled labour".

These theoretical considerations are now to be examined by means of descriptive and multivariate analyses. For the bivariate analyses it is possible to refer to information from the IAB establishment panel about the organisational units with additional demand for skilled personnel, the reasons for rejecting applicants and the ways in which firms respond to unfilled vacancies. This gives indications of certain areas which are particularly affected by the problems associated with finding skilled personnel. Furthermore it is possible to draw conclusions regarding search behaviour. The theoretical considerations are validated in the

course of the multivariate analyses. For this a linear model can be developed. First of all, however, the data from the IAB establishment panel which were used are described in more detail.

3 The IAB establishment panel

The IAB establishment panel has been conducted on commission for the Institute for Employment Research (IAB) of the Federal Employment Service (Bundesanstalt für Arbeit) since 1993 (cf. Kölling 2000). The population from which the sample is drawn consists of all establishments with at least one employee in employment subject to social security contributions, from 1993 to 1995 only in western Germany, as of the fourth wave in 1996 also in eastern Germany. Firms with no employees in employment subject to social security contributions, e.g. so-called nominally self-employed people[1], firms solely with workers insured with independent social insurance bodies (miners, farmers, artists and entertainers, publicists) and departments of the public sector which employ solely civil servants are therefore excluded from the population. By merging the data from the employment statistics, which are available as a result of the employers' compulsory reports to the social insurance agencies, via a so-called establishment number (as an "account" in which all data regarding the workers in employment subject to social security contributions are entered), it is possible on certain reference dates to differentiate the local "establishment units" regarding various characteristics such as membership of an industry and establishment size. The sample is drawn stratified according to 20 industries and 10 establishment sizes, using the procedure of 'optimal proportions' (to minimise variance). In order to depict new businesses, establishments that have hired a worker in employment subject to social security contributions for the first time are added to the panel each year. At regular intervals a supplementary sample is drawn additionally in order to compensate for the effects of panel mortality. The panel is largely regionalised, i.e. detailed analyses are possible for most of the *Länder* (States). In the 8th wave (2000) it was possible to include approximately 14,000 establishments in the survey. This is roughly equal to 0.6% of the establishments with 9.5% of the workers in employment subject to social security contributions in Germany.

The data set has already been used in a number of studies which have been published in the IAB Topics series. These include analyses of firms' employment expectations (Bellmann 1997), analyses of the productivity differences between eastern and western Germany (Bellmann & Brussig 1999), studies on enterprise flexibility (Bellmann, Düll et al. 1997), on company wage determination (Bellmann & Kohaut 1995) and on the development of new firms (Brixy & Kohaut 1998).

The survey conducted in 2000 focussed on the subject of "skill needs and personnel management". For this the establishments were asked among other things about the number of vacancies that they were unable to fill in the first six months of the year. This total was then split into individual qualification groups. In addition to other groups the number of unfilled vacancies for qualified employees with vocational qualifications and for qualified employees with university or polytechnic qualifications could be given. As a sub-group of workers with university or polytechnic qualifications, the survey also asked about the number of unfilled

[1] What is understood by nominally self-employed are workers who appear to be self-employed but whose relationship to their generally one and only client is closer to that of a dependent employment relationship.

vacancies for groups of particular interest such as engineers, computer scientists and mathematicians.

In the first six months of 2000, Germany's firms hired some 2.125 million workers. Another 570,000 people could have been taken on if all the vacancies[2] had been filled. This means that for various reasons the firms were unable to fill approximately one in five of the jobs offered (over 21%) as of the reference date of the survey (30.06.2000). This included around 64,000 posts for university or polytechnic graduates and over 37,000 for engineers, computer scientists or mathematicians. On the survey reference date this means an unfilled vacancy rate for these two groups of over 24% for graduates in general and approximately 37% specifically for engineers, computer scientists and mathematicians. Referring to the establishments, over 11% of them (more than 240,000) were not able to fill all their vacancies in the first half of 2000. Approximately 1% of the establishments (about 26,000) were seeking additional employees with university or polytechnic qualifications.

The absolute figures of this analysis are considerably lower in some cases than those of other studies on the subject of skill needs. In these other studies, however, the figures on the stock of IT specialists already fluctuate between 300,000 and over 3 million workers (cf. for example Input Consulting GmbH 2001, 15ff.). Without going into the methodical details of these studies, some brief information concerning the quality of the data used for the present study follows here.

1. The IAB establishment panel is the most extensive survey to date that has been used to examine this subject in Germany. It includes information on all industries and establishment size classes. According to an analysis of the sample that forms a basis for the panel, there are no biases affecting the representativeness of the survey (cf. Hartmann & Kohaut 2000). The survey was conducted in the context of a general establishment survey. This means it can be assumed that not only establishments that are especially affected by the issue have been put into the sample. The answers obtained in personal interviews, the method used in this survey, are generally more precise and are not based so much on respondents' estimates. Furthermore the IAB establishment panel demonstrates a very high response rate compared with other surveys.
2. The results of the IAB establishment panel for key structural results (employment structure and figure, structure and number of hirings) are in accord with the results of other official statistics (employment statistics, microcensus[3]).
3. The information from the IAB establishment panel refers to the strict formal criterion of qualification, i.e. only workers with qualifications as engineers, computer scientists or mathematicians are counted. The advantage of such a procedure is a higher level of precision and greater validity of the answers.

The following descriptive analysis first gives a general picture of the problems faced by firms when filling vacancies. Then the fields of activity in which positions for qualified staff could not be filled in the first half of 2000 are examined in more detail. In addition the reasons for vacancies not being filled and the ways in which firms respond to the lack of qualified staff are then examined. In Section 5 the theoretical model is checked using a multivariate model.

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[2] In the following the sum of the filled and unfilled jobs are defined as vacancies in the first six months of 2000.

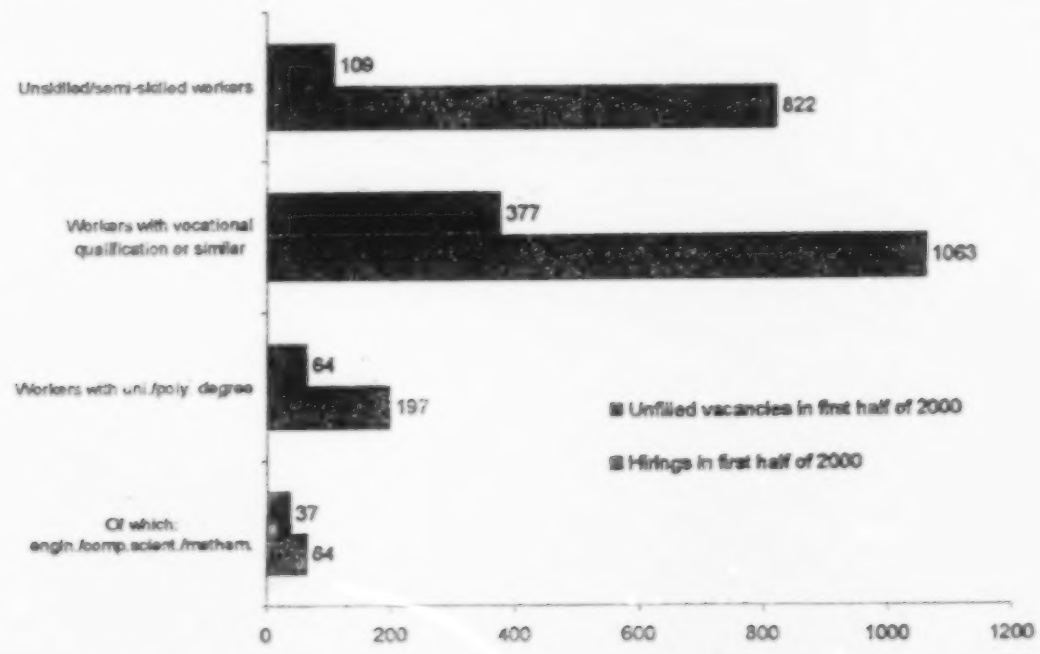
[3] cf. Federal Statistical Office, Fachserie 1, R. 4.1.2, 1999, p. 95.

4 Descriptive analyses

4.1 Hirings and unfilled vacancies

In the survey a distinction is made among other things between unskilled and semi-skilled workers, qualified workers with vocational qualifications or similar, and workers with university or polytechnic qualifications (Figure 1). Of the latter, engineers, computer scientists and mathematicians are presented as a particularly interesting group. Roughly half of all hirings (more than one million) concerned qualified workers with vocational qualifications. In addition more than 800,000 unskilled and semi-skilled workers were hired in the first half of 2000. Some 200,000 of the hirings in the first six months of 2000 concerned graduates, 60,000 of whom were engineers, computer scientists or mathematicians. This order did not change in the case of unfilled vacancies, either, although there were considerable changes in the intervals. About two thirds of the unfilled vacancies were advertised for qualified workers with vocational qualifications (approximately 375,000). By comparison there were only about 100,000 vacancies for unskilled and semi-skilled workers and over 60,000 vacancies for graduates. The graduate vacancies included some 37,000 posts for engineers, computer scientists and mathematicians. These figures of course also reflect the orders of magnitude within employment as a whole. According to the 1999 microcensus there were some 17.3 million gainfully employed workers with vocational qualifications, whilst approximately 4.2 million had a degree from a university or polytechnic. Furthermore the hiring behaviour is very cyclical for some qualifications (cf. Hamermesh 1993, 205). The lower the qualification of the worker concerned, the more probable it is that he or she will lose a job in a recession and be hired in an upturn. Therefore it is only possible to a limited extent to draw conclusions about the significance of the additional need for qualified employees from the absolute figures.

Figure 1: Hirings and unfilled vacancies by qualifications (in 1000s)



Source: IAB establishment panel 2000

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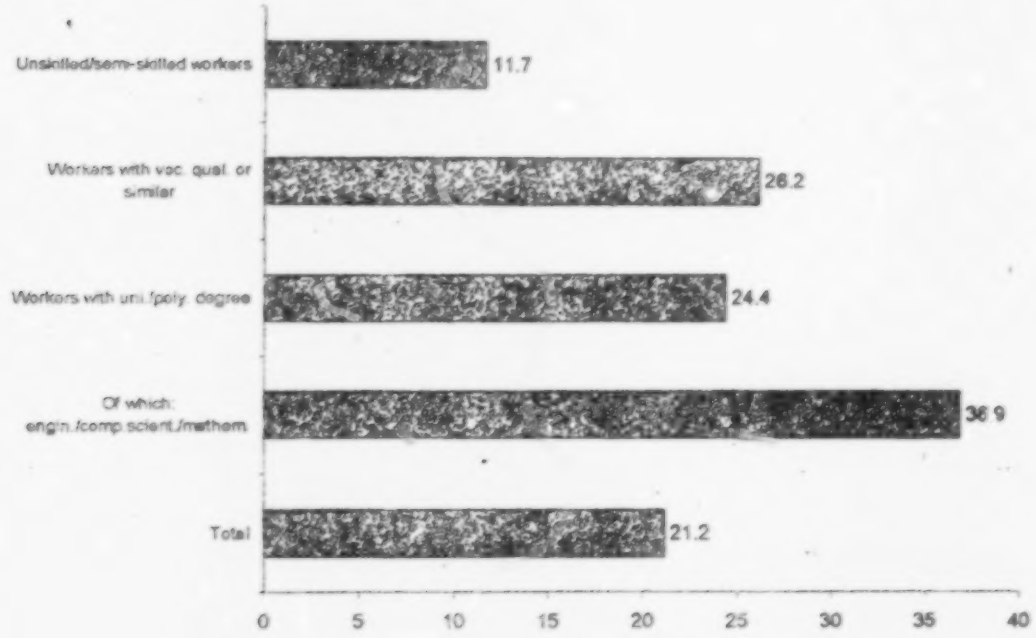
In Figure 2 the unfilled vacancy rates are broken down according to individual qualifications. It becomes clear that qualified workers with vocational qualifications and graduates show far greater proportions of unfilled vacancies than unskilled and semi-skilled workers. Whereas in the first two groups about one in four jobs could not be filled, the value for unskilled and semi-skilled workers was just over 10%. The value for qualified workers with vocational qualifications is even slightly higher than that for polytechnic and university graduates. When the group of engineers, computer scientists and mathematicians is examined specifically among the graduates, a far higher unfilled vacancy rate of approximately 37% results. Thus the demand for qualified employees in this case is particularly poorly met. The three groups with disproportionate unfilled vacancy rates should therefore now be examined by industry and establishment size.

Figure 2: Unfilled vacancies as a proportion of all possible hirings by qualifications (%)



Source: IAB establishment panel 2000

It becomes clear from Figure 3 that especially very small establishments have trouble recruiting qualified staff. In the case of large firms not only the unfilled vacancy rate for qualified staff with vocational qualifications falls, but also that for graduates. The proportion of unfilled vacancies for engineers, computer scientists and mathematicians among all vacant posts in the first half of 2000 decreases too, but not so strongly. At least three out of ten vacancies remain unfilled on the reference date of the survey. In contrast, the proportion of unfilled vacancies for qualified workers with vocational qualifications in firms with more than 1000 employees falls from over 40% in the smallest establishment size class to below 10%.

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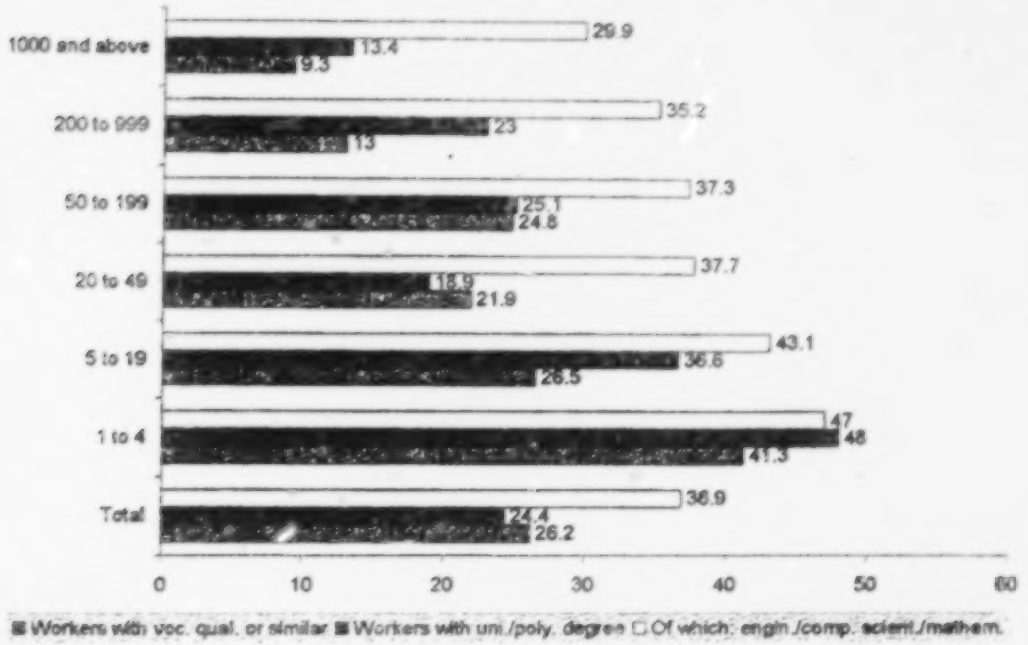
Figure 3: Unfilled vacancies as a proportion of all possible hirings by establishment size and qualifications (%)



Source: IAB establishment panel 2000

When examining the situation by industry (Figure 4) it stands out that in the business-related services, in financial intermediation and in the transport and communication sector there are above-average unfilled vacancy rates both for qualified workers with vocational qualifications and for graduates. The same is true of manufacturing but with the qualification that engineers, computer scientists and mathematicians are not affected by it. In the transport and communication sector almost 60% of the jobs for this group remain unfilled. In non-profit organisations the figure is over 43%, in business-related services and financial intermediation it is approx. 40%. By contrast, in the transport and communication sector graduates, especially engineers, computer scientists and mathematicians are of importance. The public sector also appears to have great trouble filling posts for polytechnic and university graduates. This sector does not seem to be very attractive especially for engineers, computer scientists and mathematicians, as the rate of unfilled vacancies here is over 43%.

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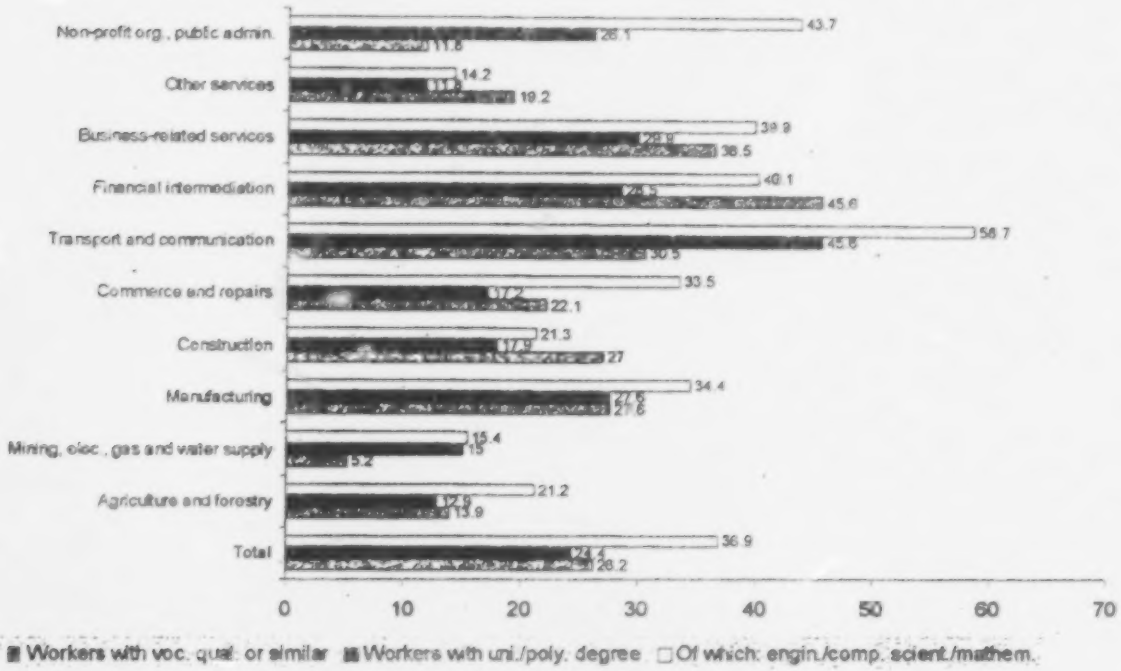
Figure 4: Unfilled vacancies as a proportion of all possible hirings by industry and qualifications (%)



Source: IAB establishment panel 2000

It is possible to look at the matching problem from viewpoints other than those seen so far. Other factors, too, are important for assessing the problem, for instance the organisational units in which the qualified personnel are sought. In addition to this the reasons for rejecting applicants and the response of firms to unfilled vacancies are of particular interest when analysing the process of filling jobs. The following account refers only to firms in which additional qualified workers with vocational qualifications or with a polytechnic or university degree are being sought. First of all Section 4.2 takes a look at the organisational units with unfilled vacancies in the first six months of 2000.

4.2 Organisational units and fields of activity with unfilled vacancies

Whilst qualified staff who have vocational qualifications or similar are sought especially in production, in services, and in repair and maintenance, it is graduates who dominate in firms which have been seeking employees for the fields of information technology, data processing and research and development. In addition the area of service, customer advice etc. is of great importance for both of the qualification groups. The deployment possibilities for university and polytechnic graduates seem to be broader, however, as roughly one third of the firms with unfilled vacancies for graduates wish to employ the graduates in "other" organisational units, whereas just under half of the firms additionally seeking personnel with vocational qualifications demonstrate a need for production or services.

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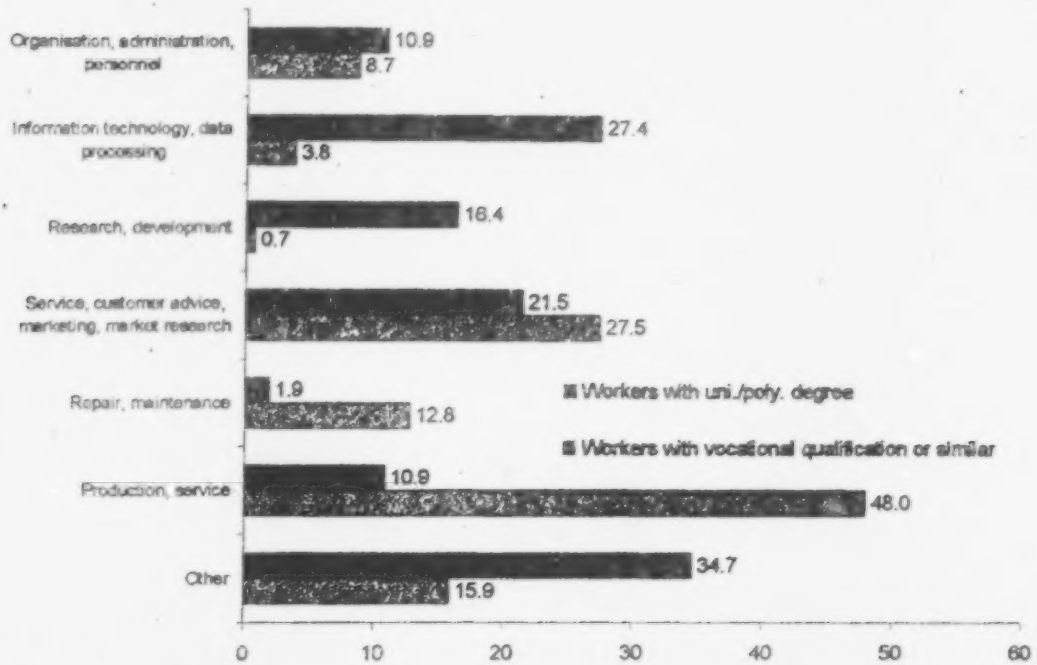
Figure 5: Proportion of the establishments with vacancies by qualifications and organisational units (%)



Source: IAB establishment panel 2000

Figures 6a and 6b put into concrete terms the information from Figure 5 for the manufacturing industry and for technology-intensive service industries. Here the business-related services, financial intermediation and the transport and communication sector are counted as technology-intensive services. Figure 6a contains the details for qualified workers with vocational qualifications. Considerable differences can be seen compared with the cross-sectional values for the economy as a whole. In the case of technology-intensive service industries there is a disproportionate number of unfilled vacancies in organisation and administration, in information technology and in the service field. In the manufacturing industry, on the other hand, many of the jobs in the fields of maintenance and production and in services could not be filled. The picture is somewhat different for graduates (Figure 6b). In both of the industries examined there is an above-average number of unfilled vacancies for the fields of information technology and data processing, research and development and the service sector, although the main focuses differ. The technology-intensive service industries dominate in the field of information technology, whereas in the manufacturing industry the emphasis is on the field of research and development.

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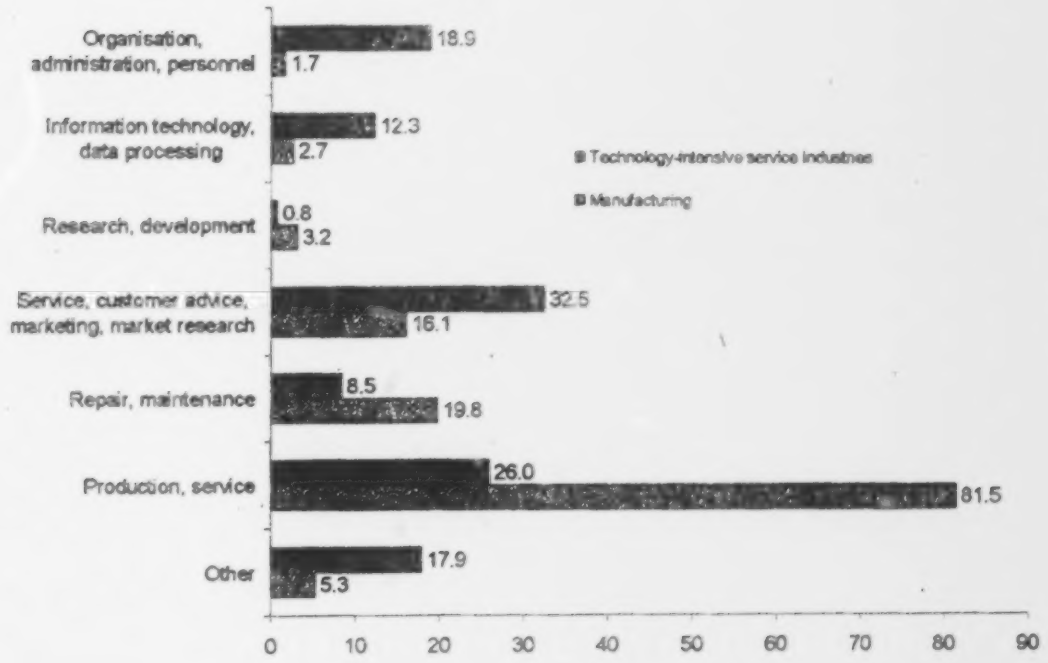
Figure 6a: Proportion of firms with vacancies for qualified staff with vocational qualifications by organisational units in manufacturing and the technology-intensive service industries



Source: IAB establishment panel 2000

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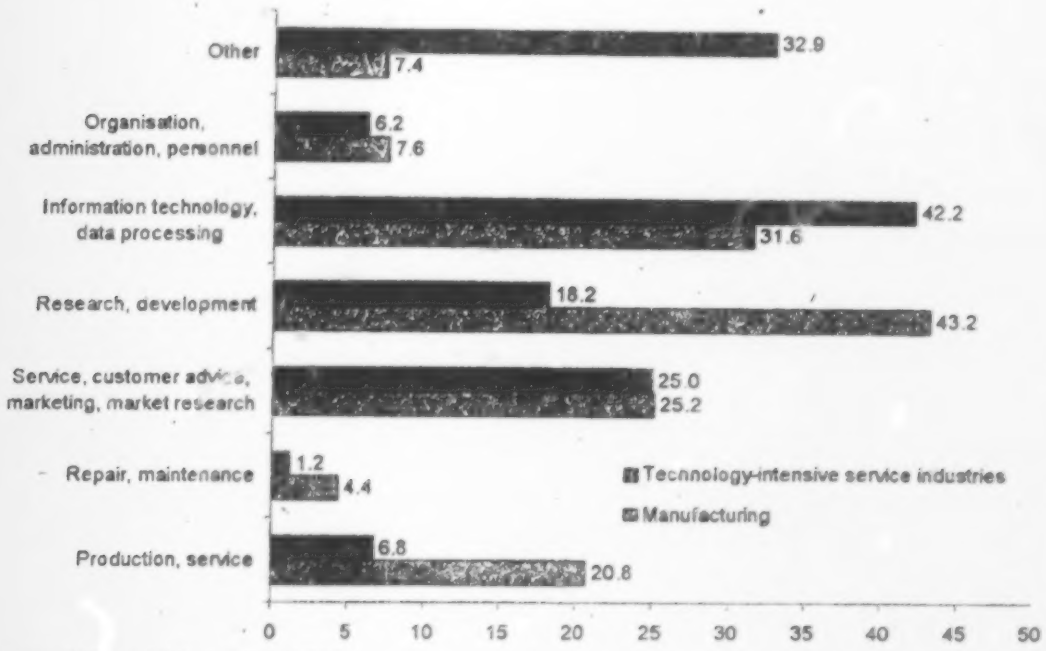
Figure 6b: Proportion of firms with vacancies for graduates by organisational units in manufacturing and the technology-intensive service industries



Source: IAB establishment panel 2000

4.3 Reasons for vacancies not being filled

The reasons for rejecting applicants are similar for workers with vocational qualifications and for university and polytechnic graduates. The most common reason cited for not filling vacancies for both of the groups was a lack of applicants. Firms that were unable to fill all of their jobs seem to suffer from great problems in their search for suitable staff. Approximately 43% and 41% of the firms respectively cite this answer. With a clear interval the next answers given are a lack of vocational training, little work experience and a lack of knowledge of the particular industry. In each case more than 20% of the firms also report overly high wage expectations as a reason for rejecting applicants. Although in each case more firms seeking staff with vocational qualifications make use of the response possibilities, apart from the reason "incompatible wishes regarding working hours" there are no more serious differences. Here far more firms seeking staff with vocational qualifications answer than firms with vacancies for graduates. Perhaps shiftwork, which is more widespread for workers in industry, is of importance in this respect. In contrast, the age of the workers sought is rarely cited as a reason.

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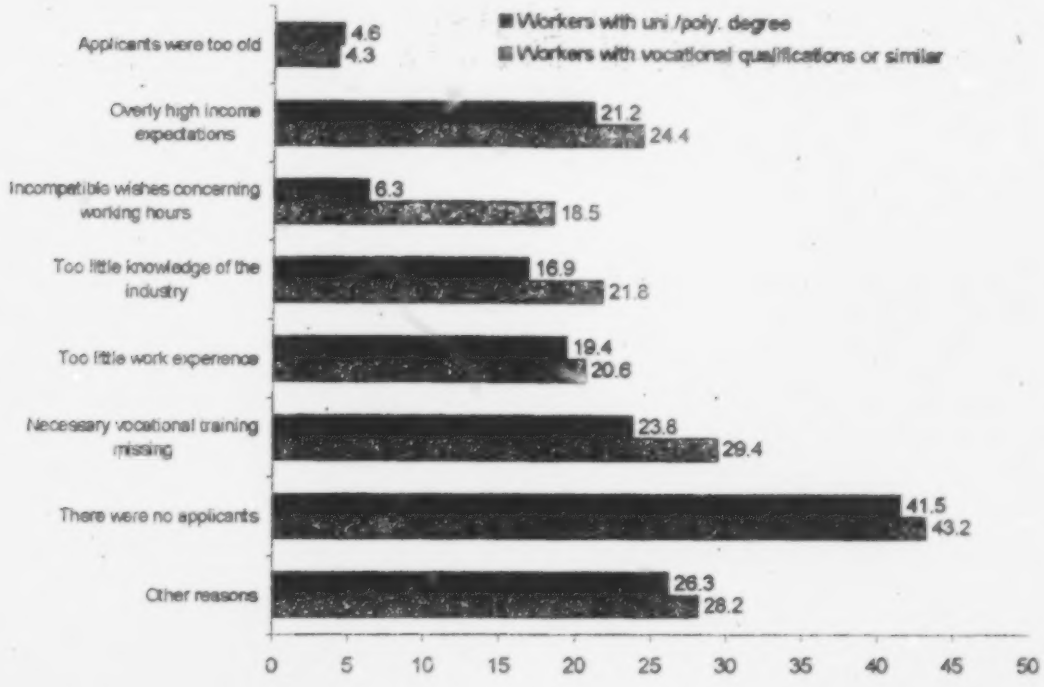
Figure 7: Proportion of firms with vacancies by reasons for rejecting applicants (%)



Source: IAB establishment panel 2000

The reasons for rejecting applicants are also differentiated according to the manufacturing industry and the technology-intensive service industries in the following. In the case of unfilled vacancies for qualified workers with vocational qualifications (Figure 8a) it stands out that too little work experience and a lack of the required vocational training are cited with above-average frequency in both industries. What is remarkable is the fact that compared with the overall value, in the manufacturing industry there are above-average proportions of the responses of too little knowledge of the industry and applicants too old. In contrast, lower rates are found for incompatible wishes regarding working hours and little knowledge of the industry among firms in the technology-intensive service industry.

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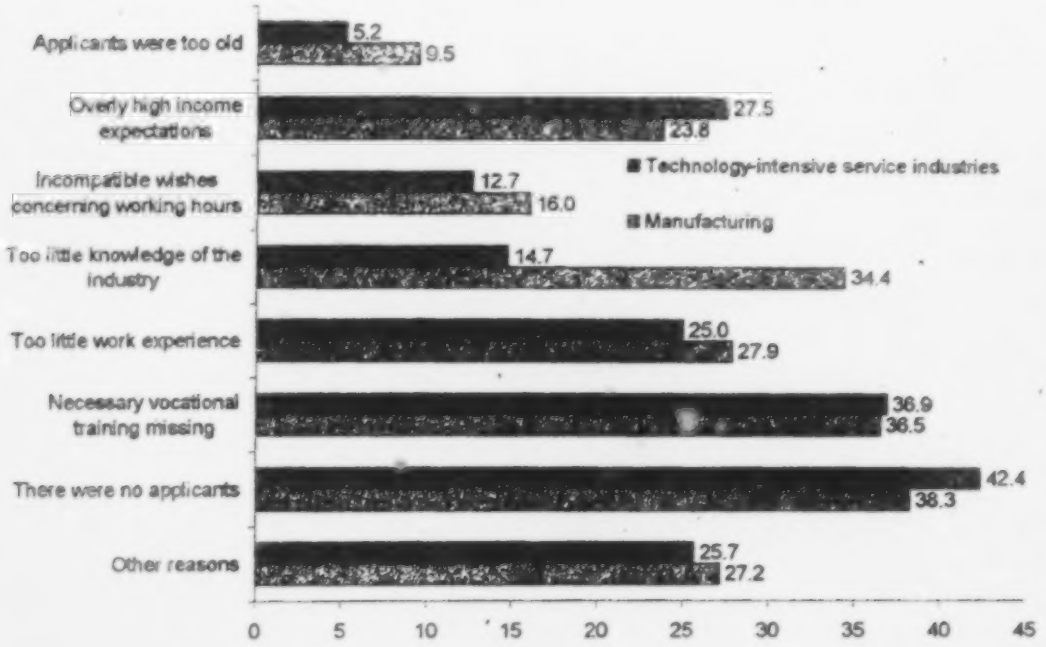
Figure 8a: Proportion of firms with vacancies for qualified staff with vocational qualifications by reasons for rejecting applicants in manufacturing and the technology-intensive service industries



Source: IAB establishment panel 2000

When there are job vacancies for graduates (Figure 8b), some considerable differences become noticeable compared with the results shown in Figure 7. About two thirds of the firms in the manufacturing industry report that there were no applicants for their unfilled vacancies. On the other hand, firms in the technology-intensive service industry increasingly complain that applicants have overly high salary expectations and a lack of vocational training. In contrast, incompatible wishes concerning working hours are no longer of any significance in either of the two industries.

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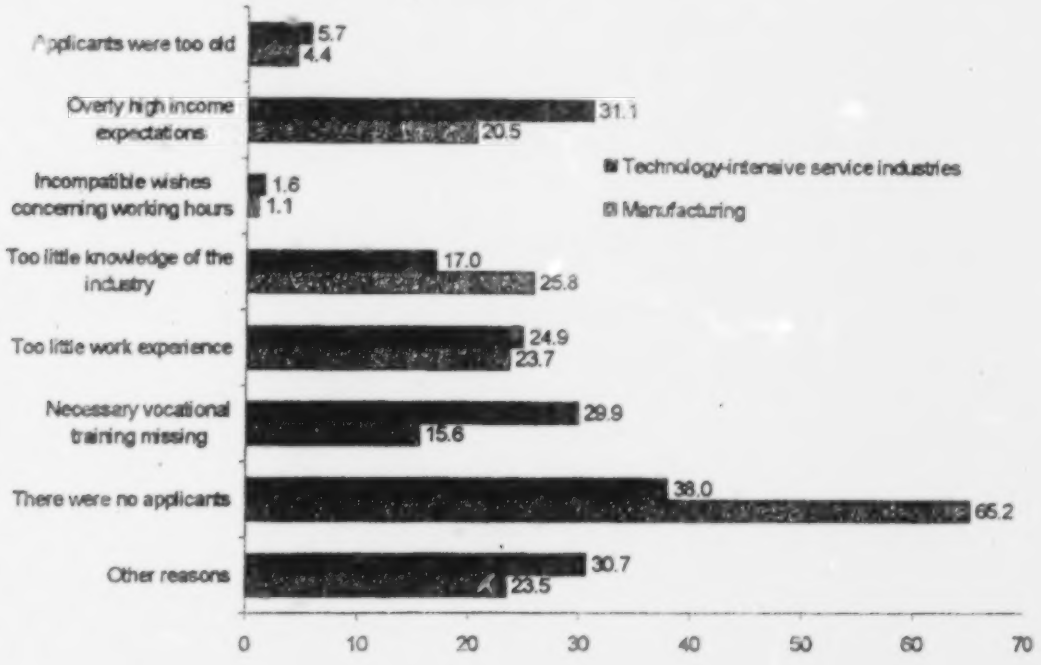
Figure 8b: Proportion of firms with vacancies for graduates by reasons for rejecting applicants in manufacturing and the technology-intensive service industries



Source: IAB establishment panel 2000

4.4 The response of firms to unfilled vacancies

The most common way in which firms respond to unfilled vacancies is to arrange for more overtime, though this method is used far less in firms seeking graduates (roughly 50% of the firms seeking workers with vocational qualifications and 33% of the firms wishing to recruit graduates). It must be taken into consideration here, however, that workers with higher qualifications work more unpaid overtime. Apart from "other measures", firms seeking workers with vocational qualifications have frequently turned down orders (approx. 23%) and have transferred employees within the firm (about 21%). In addition to turning down orders (18%), firms with additional demand for polytechnic and university graduates also frequently respond by contracting out orders (about 22%), setting up inter-company co-operations and reinforcing their own initial and further training programmes (approx. 17% each). The firms apparently have a number of response possibilities at their disposal which may be able to raise alternative returns.

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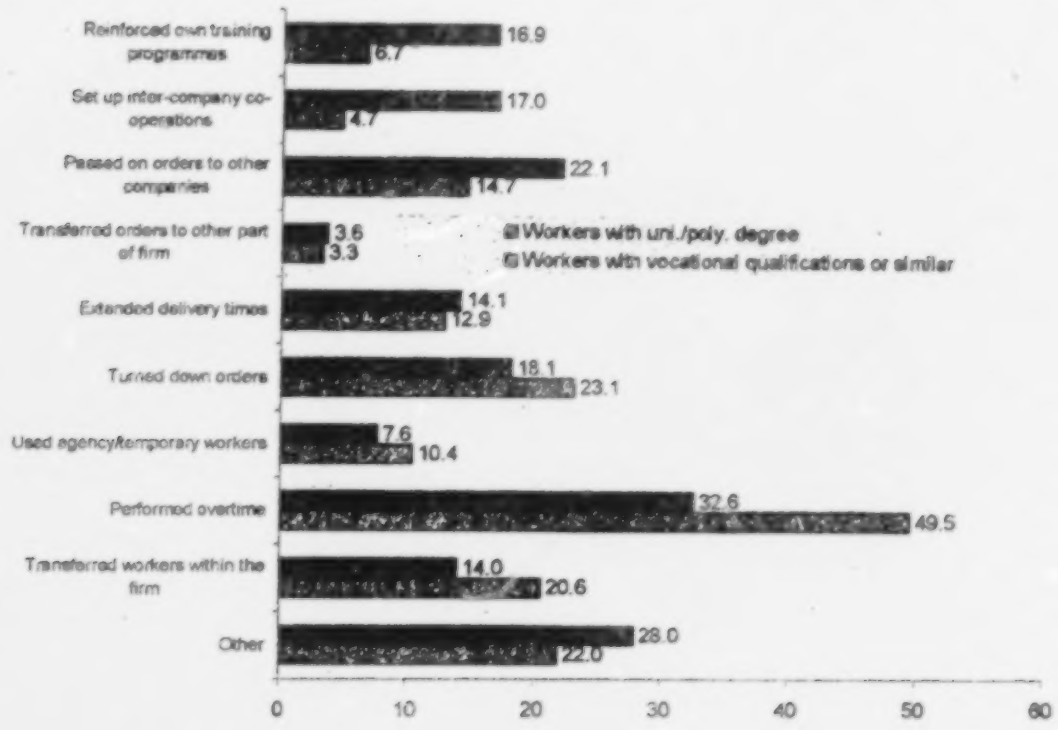
Figure 9: Proportion of firms with vacancies by responses within the firm (%)



Source: IAB establishment panel 2000

The responses of firms to unfilled vacancies also differ greatly between the firms in the technology-intensive service sector and those in the manufacturing industry. In the case of qualified workers with vocational qualifications (Figure 10a) there are above-average values for firms in manufacturing in almost all the answer possibilities. Especially the use of overtime shows this clearly. In contrast, rates below the overall average can be found for firms in the technology-intensive service sector. They also seem to be making use more of individual solutions, which are concealed behind the answer "other" and do not fit into the given selection of responses. Only in the firms' own initial and further training activities do both industries lie above the rate for all firms.

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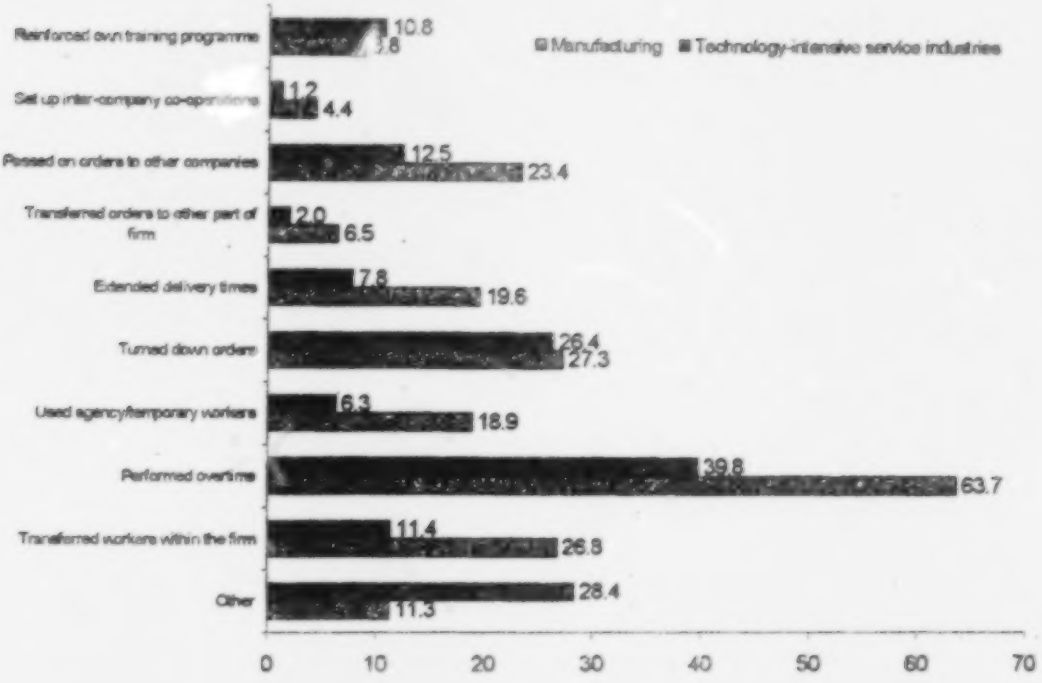
Figure 10a: Proportions of the firms with vacancies for workers with vocational qualifications by responses within the firms in manufacturing and the technology-intensive service industries



Source: IAB establishment panel 2000

For jobs that are to be filled by graduates (Figure 10b), there are also differing response patterns in the firms of both industries. Compared with the average of all units in Figure 9, firms in the technology-intensive service industries more often opt for contracting out orders, extending delivery time and turning down orders. Firms also reinforce their own initial and further training to an above-average extent, however. In manufacturing on the other hand, overtime and temporary and agency workers are frequently used when there are unfilled vacancies for graduates. Transfers within the firm are also made. This makes clear once again the different strategies used in the two industries.

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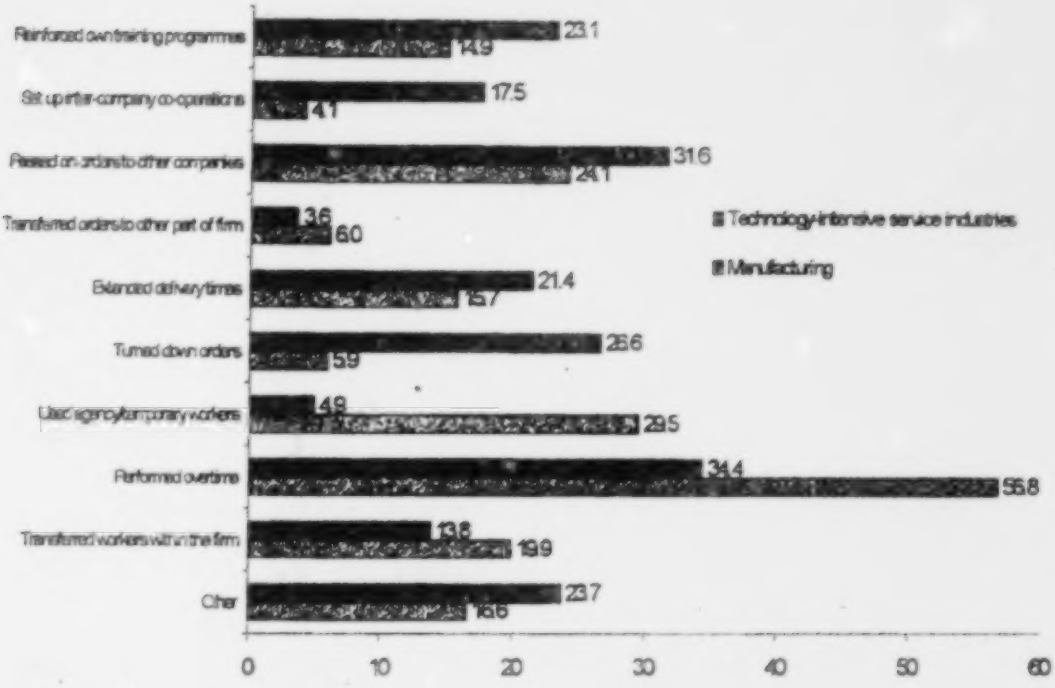
Figure 10b: Proportions of the firms with vacancies for graduates by responses within the firms in the manufacturing industry and technology-intensive service industries



Source: IAB establishment panel 2000

5 Multivariate analysis of firms' search behaviour

A number of details from the IAB establishment panel are available for the multivariate analysis of firms' searches for personnel. Usually the probability of filling a vacancy is put in relation to the time taken to fill a job vacancy. Here it is assumed that the inverse probability of filling the vacancy is equivalent to the duration of the vacancy (cf. for example Burdett & Cunningham 1998). Unfortunately this information is not available from the IAB establishment panel since it would be too much to expect of the firms to answer questions regarding the duration of all vacancies. In order not to provoke a refusal to answer, such questions are therefore left out. There is also the fact that firms are often unable to give exact figures for the search times. They often make estimates, quite frequently giving "rounded" search times such as whole weeks or months (Burdett & Cunningham 1998, 450f.). In addition, the duration of jobs that have already been filled refers to past events. It is possible that the search is then not analysed for the time of the survey but for a previous point of time.

If one assumes otherwise equal conditions between two firms, then the number of unfilled vacancies can also be used as an instrument for the probability of filling the vacancies. With identical firms there should also be *ceteris paribus* an equal number of unfilled vacancies. If there are differences, there should be differences in the search behaviour. Here, however, it is not taken into account how long the jobs under investigation have already been vacant and

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how long they are yet to remain unfilled. Completely different structures may be concealed behind the same number of job vacancies so that one firm could have more long-term unfilled vacancies whilst the other firm is able to fill the vacancies very quickly. Therefore in order to be able to make the following estimates it is assumed that there is no systematic distribution of long-term and short-term vacancies. One can, however, start out from the assumption that the survey records more vacancies with longer durations than those with shorter durations, as the probability of recording vacancies increases with the duration of the vacancies in a reference date examination. In order to take into account differences between the individual qualification levels, separate estimates are carried out in addition for graduates and for qualified workers with vocational qualifications. Furthermore the firms' expected turnover is incorporated into the estimate so that the differing economic developments can be portrayed.

The likelihood of an application being addressed to a firm at all is to be portrayed by several company characteristics. 38 industry dummies and the logarithm of establishment size in linear, quadratic and cubic form are used as variables. For this non-profit firms and firms with fewer than five employees are excluded. In order to take regional particularities into account, firstly an east/west dummy and secondly 10 variables indicating regional demographic structure are added to the model. The variables indicating regional demographic structure are dummy variables which show especially the regional population density and the degree of agglomeration of the region where the firm is located.

From the IAB establishment panel there are no direct indications regarding the firms' search efforts. Therefore in a multivariate analysis it is necessary to look for a variable which is closely related to the efforts made to overcome the additional demand for qualified staff. For this reason the number of trainees was selected as an instrument for the search efforts. If the firms are prepared to take on the great expense involved in training employees, one might assume their other search efforts to be quite considerable too. Then the variable would be highly correlated with the search efforts and suitable as an instrument.

The attractiveness of the job can be expressed by means of the wage rate. Here, however, a problem becomes noticeable which is associated with a sequential form of the search. As the search duration increases, so too could the wage offer increase so that the job grows in attractiveness. If the job nonetheless remained unfilled, a positive relationship between the wage rate and the number of unfilled vacancies would be measured instead of a negative one. The instrument of pay using the wage rate of the previous period is associated with a great loss of observations as many firms have taken part in the survey for the first time. It is unlikely, however, that the wage rate for unskilled workers increases if highly qualified staff are sought for a longer period of time. Then the wage rate of the low-skilled would be a suitable instrument to describe the effect of pay. For this reason the panel information is divided into qualification-specific labour costs by means of a regression procedure[4]. An attractive wage level in a firm is given when a relatively high wage rate is also paid to low-skilled employees.

The minimum qualification level for applicants is often determined by the technical equipment and the organisation of labour in the firms. If the assumption is followed here that technological or organisational changes lead to an increase in the demand for more highly qualified staff and thus to a change in the employee structure (skill biased technological or organisational change), investments in information and communication technology (ICT) or

[4] cf. Kaiser (2000). The results of the estimate are available from the author.

organisational changes in the firm can be used as variables for the minimum qualification requirements.

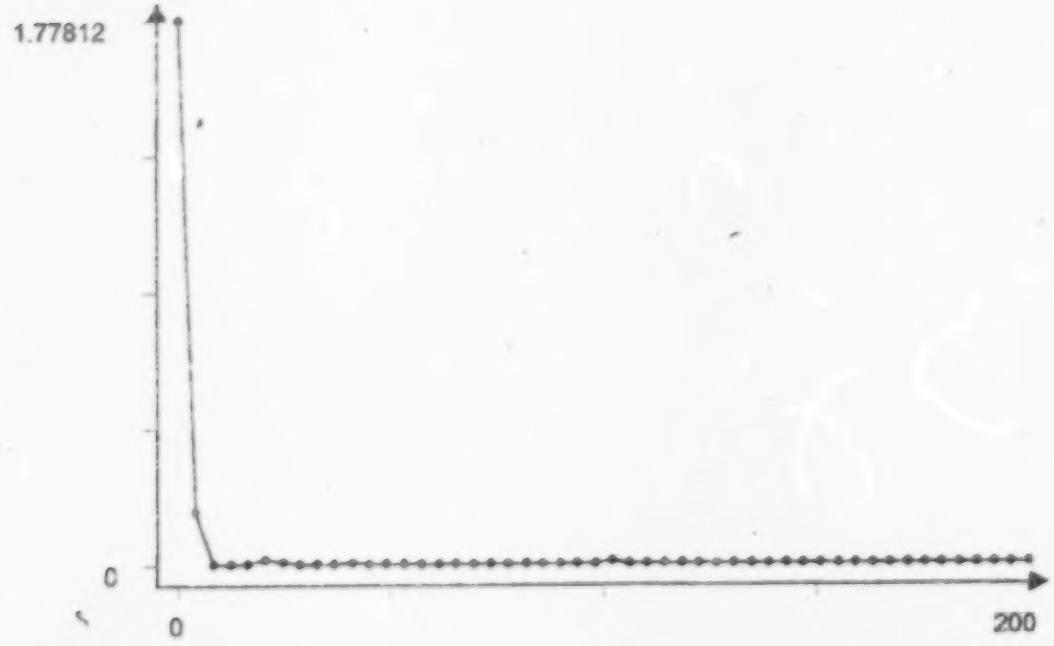
If all the named variables are taken into account, the following model results:

(1) $nbs = f(akad, w, tech, org, aus, umserw, size, size^2, size^3, branche_i, bik_j, westost)$.

with nbs: total number of unfilled vacancies
w: wage rate per capita (log.). Instrumented in the regression of individual qualification groups by estimated labour costs for unskilled workers
tech: investment in ICT (in DM millions).
org: dummy for whether organisational changes have been carried out in the last 2 years.
aus: number of trainees.
size: number of employees.
$branche_i$: industry dummies (38 forms).
bik_j: dummies for characteristics indicating regional demographic structure (10 forms).
westost: dummy for whether the firm is located in western Germany.

A look at the distribution of the unfilled vacancies shows, however, that it might not be a continuous linear variable but is more a case of count data, i.e. there are only integers so that one can assume a discrete nature of the dependent variables. In addition the number of unfilled vacancies can not become negative and most of the values are zero or almost zero (cf. Figure 11).

Figure 11: Kernel density function of the number of unfilled vacancies in the first half of 2000



Source: IAB establishment panel 2000

One way to estimate such a model with count data is to use the Poisson regression. This assumes that the conditional dependent variable follows a Poisson distribution (cf. Winkelmann 2000, 65ff.):

$$(2) \qquad y_i|x_i \sim \text{Poisson}(\lambda(x_i)),$$

where y_i is the conditional distribution of the dependent variables with given forms of the vector of the independent variables x_i. The expected value of $y_i|x_i$ is then given by:

$$(3) \qquad E(y_i|x_i) = \lambda(x_i) = \exp(x_i'\beta).$$

The parameters can be interpreted here as a relative change in the dependent variable concerning a marginal change in the independent variables:

$$(4) \qquad \frac{\partial E(y_i \mid x_i) / \partial x_{ij}}{E(y_i \mid x_i)} = \beta_j$$

The results of the Poisson regressions for the total number of unfilled vacancies, the number of unfilled vacancies for graduates and the number of unfilled vacancies for workers with vocational qualifications can be found in the appendix.

In the estimates one can see some interesting differences between the total number of unfilled vacancies and the individual qualification groups. A higher rate of pay results in a drop in the number of unfilled vacancies. This result is particularly true of the group of graduates. Organisational changes and investment in ICT also have different effects in the individual estimates. Both of the factors have a positive effect on the number of unfilled graduate positions whilst the number of unfilled vacancies for workers with vocational qualifications only increases as a result of investment in ICT. In comparison with all unfilled vacancies, organisational changes can be seen to have a far greater effect in the case of graduates. Whereas the number of unfilled vacancies overall rises by 25% in the case of changes in company organisation, the value for graduates rises by more than 55%. Investment in new technologies on the other hand has a greater effect for workers with vocational qualifications. Here the number of unfilled vacancies increases by half a percent if the investment total is raised by one million DM, whereas the number of unfilled graduate positions rises by 0.3%. Unlike with organisational changes, however, the effects seem to be very slight.

The internal training of workers seems to have no effect on the number of unfilled vacancies. Expectations of increasing turnover and features concerning the structure of the firm, however, show a significant effect on the number of unfilled vacancies. What is also interesting is the fact that the location of the firms in western or eastern Germany is not of importance for the search for graduates. For the overall number of unfilled vacancies and for the unfilled vacancies for workers with vocational qualifications, on the other hand, the number of workers needed rises by more than 50% if the firm is in western Germany.

6 Summary

This paper deals with the current debate surrounding the demand for qualified workers. It attempts to explain the so-called skill-shortage using a model of firms' searches for manpower. Usually the firms in these models have the possibility to lay down an optimal search strategy by selecting a minimum qualification level. If, however, there are external minimum guidelines for the workers' individual abilities, then it might no longer be possible to implement such an optimal search strategy. Depending on the situation the firm must either intensify its search efforts or make the job more attractive in order to increase the contact probability with the potential employees. If the costs of these additional search efforts are too high the firm may give up the systematic search for certain workers and hope that applicants with suitable qualifications may apply by chance.

The approach is tested empirically using data from the IAB establishment panel for 2000. The descriptive analyses show that many of the hirings and the unfilled vacancies apply to workers with vocational qualifications. Highly qualified staff are sought to a lesser extent in quantitative terms. This corresponds with the proportions that these groups occupy among the entire labour force, however. In the case of the relative unfilled vacancy rates, however, it can be seen that especially jobs for engineers and computer scientists are more difficult to fill than others.

The results of the multivariate analyses confirm in broad parts the assumptions of the theoretical model. Firm-specific characteristics and the attractiveness of the job are of importance in filling vacancies especially for the highly qualified. The number of unfilled vacancies for graduates tends to be higher in centres and in knowledge-intensive industries. For this group there does not seem to be a west-east effect. Technological progress and organisational changes also have a significant influence, although organisational changes affect the search for highly qualified staff more whereas when modern technologies are used there is a greater search for workers with vocational training. On the whole the results confirm the analyses of other qualitative and quantitative studies (Beckmann & Bellmann 2000, ZEW 2001, Hielscher 2001).

The findings signalise that the so-called "skill-shortage" concerns the results of companies' processes of searching for highly qualified staff in a labour market which is becoming tighter for the firms. As a result of the use of modern technologies and organisational changes in the firms, a strong demand for highly qualified staff appears to have arisen. The firms' searches, which may not have been so intensive in times of a large supply of workers, must first adapt to such a situation. Several steps within a sequential procedure are probably necessary to obtain reliable information about the labour market. It remains to be seen whether complaints about a skill-shortage will continue if the growth in certain sectors of the economy slows down, or whether the firms' search will become easier again, thus causing the public debate to subside. In the long-term of course the development of the supply of labour plays an important role. This concerns not only the university and polytechnic graduation figures e.g. of engineers, but also the demographic development within Germany and migration to Germany.

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8 Appendix

Poisson regressions of the number of unfilled vacancies in the first six months of 2000 (private sector, firms with 5 or more employees)

	Overall	Graduates	Workers with vocational qualification
Number of unfilled vacancies for graduates	0.035*** (12.439)	-	-
Remuneration per head (log)	-0.040 (0.457)	-0.087** (2.158)	-0.089 (0.550)
Investment in ICT (DM millions)	$0.24 \cdot 10^{-2}$ (0.186)	0.003*** (2.896)	0.005* (1.789)
Organisational changes (yes=1)	0.250** (2.349)	0.565*** (3.202)	-0.088 (0.527)
Training	-0.002 (1.333)	-0.002 (1.222)	-0.001 (0.156)
Expected turnover (positive=1)	0.504*** (5.127)	0.616*** (3.674)	0.317 (1.570)
Establishment size	0.001*** (5.303)	0.001*** (6.079)	0.002*** (3.785)
Establishment size (quad.)	$-0.48 \cdot 10^{-7}$*** (4.757)	$-0.37 \cdot 10^{-7}$*** (3.511)	$-4.00 \cdot 10^{-7}$*** (3.035)
Establishment size (cub.)	$0.83 \cdot 10^{-12}$*** (4.171)	$0.54 \cdot 10^{-12}$*** (2.630)	$8.44 \cdot 10^{-12}$*** (2.825)
Industry dummies (reference: agriculture and forestry) χ^2 (df.)	309.06*** (37)	1779.52*** (37)	9991.34*** (37)
Regional structure dummies (reference: cities with more than 500,000 inhabitants) χ^2 (df.)	32.53*** (9)	18.27** (9)	21.09** (9)
West/East (western Germany=1)	0.537*** (4.285)	-0.050 (0.782)	0.542** (2.012)
Constants	0.019 (0.022)	-1.945*** (2.941)	-0.257 (0.172)
Log Likelihood	-19504.833	-5728.253	-8656.893
Pseudo R^2	0.36	0.37	0.33
Wald test for common significance of the exog. Var. χ^2 (df.)	1978.10*** (55)	2418.14*** (54)	14434.30*** (54)
Number of observations	6170	2642	3454

Source: IAB establishment panel 2000. Heteroskedasty- (White-)robust Poisson estimates. The absolute z-values are shown in brackets. (*) ** and *** signalise a level of significance of (90%) 95% and 99% respectively.

Descriptive statistics of the variables used

Variable	Obs.	Mean value	Std. dev.	Min.	Max.
No. of unfilled vacancies (overall)	7943	2.03	9.28	0	200
No. of unfilled vacancies (graduates)	3745	1.11	5.62	0	100
No. of unfilled vacancies (workers with vocational qualifications)	4848	1.05	5.30	0	180
Wage per head	12414	7.99	0.62	2.30	10.8
Wage per head for unskilled staff (log., instrumented)	9396	5.44	3.12	-2.39	8.55
Wage per head for skilled staff (log., instrumented)	7573	7.24	1.19	0	8.67
Wage per head for qualified white-collar staff (log., instrumented)	10089	8.22	0.80	0	9.94
Organisational changes in the last two years (yes=1)	13931	0.38	0.49	0	1
Total investment in ICT in 1999 (in DM m.)	13931	8.45	33.86	0	150
Number of trainees	13930	9.32	50.42	0	3337
Expected turnover	13931	0.27	0.45	0	1
Establishment size	13931	201.00	779.48	1	41638
Westeast (western German *Länder*=1)	13931	0.59	0.49	0	1

Regional demographic structure types

Category (inhabitants, location)	No. of establishments
500.000+ (core)	5,043
500.000+ (periphery)	839
100.000-499.999 (core)	2,223
100.000-499.999 (periphery)	782
50.000-99.999 (core)	654
50.000-99.999 (periphery)	348
20.000-49.999	1.676
5.000-19.999	2.172
2.000-4.999	884
below 2.000	905

Industry structure

Var.-lab.	Industry	WZ93
1	Agriculture, hunting and forestry; fishing and related activities	01, 02, 05
2	Mining and quarrying; electricity, gas and water supply	10 - 14, 40, 41
3	Manufacture of food products and beverages, manufacture of tobacco products	15 - 16
4	Manufacture of textiles and clothing; tanning and dressing of leather, manufacture of leather goods	17 - 19
5	Manufacture of furniture, jewellery, musical instruments, sport articles, toys and other products	36
6	Manufacture of pulp, paper and paper products; publishing and printing	21 - 22
7	Manufacture of wood and wood products (excl. furniture)	20
8	Manufacture of chemicals and chemical products; manufacture of coke, refined petroleum products and nuclear fuel	23, 24
9	Manufacture of rubber and plastic products	25
10	Manufacture of other non-metallic mineral products	26
11	Manufacture of basic metals	27
12	Recycling	37
13	Manufacture of fabricated metal products and structural metal products	28
14	Manufacture of machinery and equipment	29
15	Manufacture of motor vehicles, trailers and semi-trailers, and parts and accessories thereof	34
16	Manufacture of other transport equipment (ships and boats, railway and tramway locomotives and rolling stock, aircraft and spacecraft, bicycles and motorcycles and such like)	35
17	Manufacture of electrical machinery and apparatus, manufacture of radio, television and computer apparatus, manufacture of office machinery and computers and equipment	30 - 32
18	Manufacture of precision and optical instruments	33
19	Site preparation, civil engineering (equivalent to core construction industry)	451; 452
20	Building installation and other building work (equivalent to building completion)	453; 454; 455
21	Sale, maintenance and repair of motor vehicles, retail sale of automotive fuel	50
22	Wholesale trade and commission trade	51
23	Retail trade (excl. motor vehicles), repair of personal and household goods	52
24	Transport	60 - 63
25	Communication	64
26	Financial intermediation	65, 671
27	Insurance and pension funding	66, 672
28	Hotels and restaurants	55
29	Education	80
30	Health, veterinary and social work	85
31	Computer and related activities	72
32	Research and development	73
33	Legal, accounting, book-keeping and auditing activities, tax consultancy, market research and public opinion polling, business and management consultancy, holdings	741, 744
34	Real estate, renting and business activities	70
35	Renting of machinery and equipment, other services (mainly for business)	71, 742, 743, 745 - 748
36	Sewage and refuse disposal, sanitation and similar activities	90
37	Recreational, cultural and sporting activities	92
38	Other service activities such as laundry services, cleaning, hairdressing, cosmetic activities, funeral services, swimming pools, saunas, solariums etc.	93

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